USER NEEDS

The focus of this thrust is on the development of terminal seeker, sensor, and guidance and navigation technologies for weapons that can go anywhere, anytime, accurately, affordably, and autonomously. User needs have been extracted from the Air Combat Command (ACC) Mission Area Plans for Counter Air, Strategic Attack/Interdiction, Close Air Support/ Interdiction, Theater Missile Defense, and Electronic Combat.

AIR-TO-SURFACE

Smart Hard and Soft Target Munitions
Small Smart Bomb

- Autonomous target identification and tracking in weather with affordable, countermeasure resistant seekers
- Real-time targeting and damage assessment
- Steep dive angle target acquisition and tracking for penetrating munitions
- Reduced mission planning requirements
- Minimal collateral damage
- Intelligent Antijam Global Position System /Inertial Navigation System (GPS/INS) guidance

AntiMateriel Munitions

- Autonomous target identification and tracking in weather with affordable, countermeasure resistant seekers
- Real-time targeting
- Identification of friend or foe

AIR-TO-AIR

Dual Range Missile

- Increased electronic countermeasure (ECM) resistance and broader target set
- Identification of friend or foe
- Capability against cruise missiles
- Improved guidance laws/autopilots for enhanced accuracy and faster intercept
- Low cost, small, and accurate Inertial Measurement Units (IMUs)
- High off-boresight lock-on and track capability with affordable seekers

See Figure 4 for major Thrust efforts.

GOALS

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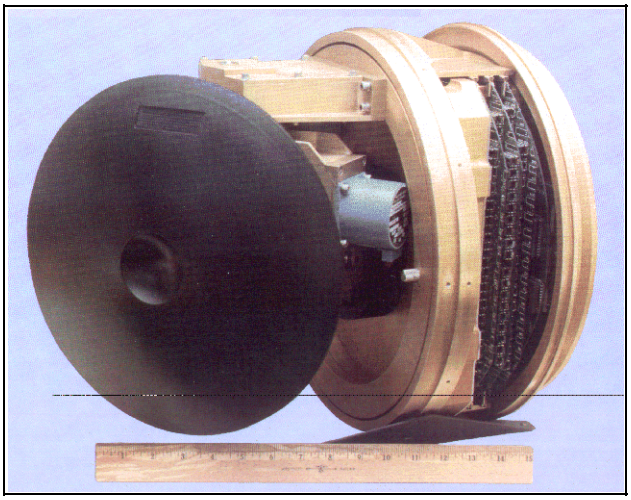

FIGURE 5. Synthetic Aperture Radar Seeker

The air-to-surface laser guided weapons currently in the inventory require designation of the target by laser. A successful mission requires not only the designator remain in the target area until weapon impact, but also the weather to be good enough to allow visual acquisition by both weapon and designator. Desert Storm highlighted this weather limitation and the need for precision guidance (minimum collateral damage). **These considerations have led to the requirement for autonomous, all-weather, countermeasure resistant, precision seekers for our weapons.**

- A near-term goal is to demonstrate a Synthetic Aperture Radar (SAR) seeker (Figure 5) capable of guiding a conventional direct attack weapon to a fixed high value target within 3 meters in adverse weather and at a cost of less than $40K per unit in quantities of 5000.

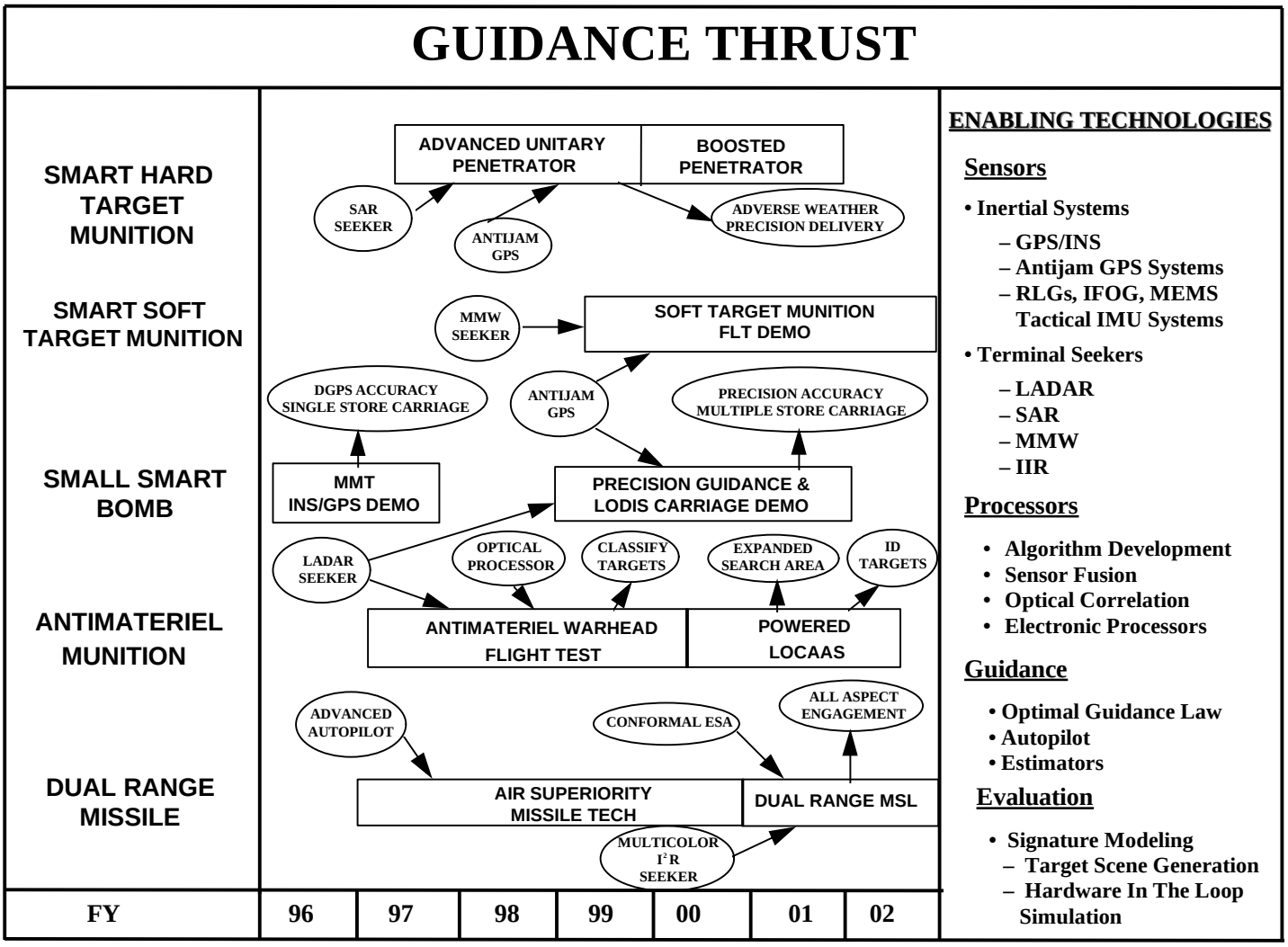

Figure 4. Thrust 1 Advanced Guidance

Real-time targeting offers mission flexibility in a rapidly changing battlefield. It allows an update in the coordinates of a mobile target as well as the opportunity to change to an alternate high value target.

Several techniques are being investigated to address this capability, to include using data from either on-board or off-board sensors. In addition, the seeker may use inputs from multiple types of sensors operating in different parts of the electromagnetic spectrum.

- A mid-term goal is to demonstrate real-time targeting for a SAR seeker using either on-board or off-board sensor information.

- Develop and demonstrate solid-state laser radar (ladar) sensor and algorithms for precision guided munitions. The Advanced Solid State Ladar (DASSL) program will develop the ladar seeker for use in the Miniaturized Munition Technology Demonstration (MMTD) Program.

- Develop and demonstrate jam-resistant, all-weather, day/night, forward-looking, wide field-of-regard, high resolution, millimeter wave, radiometric imaging sensor.

- Investigate emerging technologies in millimeter wave (MMW), LADAR, and passive infrared (IR) that add new signature detection capabilities to current seekers by the exploitation of polarization diversity and various spectral sensitivities for the different frequency regimes.

Acquiring and attacking fixed hard targets presents some unique problems. In order to employ penetrating weapons optimally, the seeker must be able to acquire the target in a steep dive angle and remain locked on until target impact**. Also, detecting damage following an attack is difficult, especially for buried or covered targets such as command control bunkers and aircraft shelters.**

- Develop seekers capable of all-weather, autonomous acquisition, and precision tracking of fixed hard targets at steep dive angles.
- Develop and demonstrate methods to obtain real time battle damage assessment for fixed hard targets.

Traditionally, mission planning for a strike against fixed high value targets with stand-off weapons can take up to several days. This timeline begins from receipt of targeting material through reference template generation to validation. Because of this, the number of sorties flown and targets attacked in a given time period is limited.

- Develop algorithms and tools for weapons which will assist in reducing mission planning times from days to minutes to increase sortie generation.

Mobile targets such as tanks, trucks, relocatable missile launchers, or radar sites have special seeker requirements for both stand-off and direct attack deliveries. To meet the user's need for defeating this broad spectrum of targets, an affordable laser radar seeker has been coupled with a multimode warhead in a maneuvering, antimateriel submunition. The seeker provides highly accurate guidance and enough information to determine which warhead mode should be used to maximize lethality on the target.

- Develop an improved, low cost seeker which combines autonomous target identification and tracking of mobile targets in weather with increased area coverage.

Distinguishing friend from foe when forces are in close contact is required for all-weather environments. To accomplish this task, the seeker must have precise angular and range resolution together with the capability to process at extremely high data rates.

- A mid-term goal is to exploit the technologies of high resolution laser radar, optical processing, and image algebra to develop new seekers. These seekers will have high speed, compact, parallel processors capable of processing high resolution images in less than 10 milliseconds and algorithms which will find and identify targets in an adverse weather, clutter/ countermeasured environment, using high resolution, solid-state, laser radar sensors.

GPS/INS guided munitions are currently being developed for direct attack and stand-off applications. GPS/INS guidance provides a low cost, highly accurate, day/night, all weather guidance system for tactical weapons. GPS/INS

weapon guidance, whether used alone or with a terminal seeker for precision accuracy, is the way of the future. The intensity of jamming encountered by a weapon is more severe than that encountered by an aircraft because of the weapon's proximity to collocated jammers at the target which could render the weapon GPS receiver useless, thus severely degrading weapon terminal accuracy.

- The goal is a low cost, small, intelligent GPS/INS weapon guidance system for weapon options which will be resistant to jamming by postulated threats.

- This thrust contains the only program within DoD that addresses the antijam GPS technology for tactical weapons. This technology supports the Joint Direct Attack Munition (JDAM) and future tactical weapons.

Low cost, highly reliable, miniature IMUs are essential for air-to-air and air-to-surface weapon options, and for GPS/INS guidance systems. The next generation of IMUs will be based on innovative micromachining technologies that lend themselves to the low cost manufacturing techniques associated with chip design and fabrication.

- Our goal is to develop, demonstrate, and mature a new generation of IMUs which are highly reliable, one-fourth the cost, and one-third the size of current systems. They will also have dual use potential for commercial sensing devices.

- To further the goal of identifying affordable concepts and components and reducing the life cycle cost of seekers, we are developing in-house research test-beds. These include MMW Reflectivity Measurement System (MRMS), Research and Seeker Emulation Radar (RASER), the Laser Radar Brassboard, and the Advanced Guidance Research Facility (AGRF).

AIR-TO-AIR

Efforts relating to medium range missiles are primarily concentrated on technologies to improve the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). These include lower cost components, increased electronic countermeasure resistance against a broader target spectrum, and identification of friend or foe.

- Develop a multimode seeker with enhanced processor hardware and algorithms to improve the target identification capability and end game accuracy.

- Provide enhanced performance against post-2000 advanced electronic countermeasures and low observable threats.

- Provide acquisition and shoot-down capability of cruise missiles.

There are current investigations underway to improve the performance of seekers for short range air-to-air missiles. The Armament Directorate is assisting in a number of technology areas to address these specific problems with emphasis on reduction of component costs.

- Develop and demonstrate a low cost seeker with an electronic, steerable, conformal array antenna to provide rapid scanning of large fields-of-regard.

In addition to the target oriented goals listed above, there are goals for support technologies which apply across the board to all target types, for both air-to-air and air-to-surface. These include developing research test-beds, modeling, and simulation tools which reduce development and life cycle testing while providing specific seeker performance information as well as overall reliability, maintainability, and supportability data.

- The goal is to develop advanced guided munition simulation and simulator technologies and techniques in order to provide reliable and affordable assessments early in the seeker development process. Advancements in simulator scene projectors, scene generation computer codes and hardware, flight motion simulators, and real-time computer hardware will significantly increase the fidelity and utility of ground test facilities and reduce the magnitude of expensive flight test programs.

Missile effectiveness can be significantly increased by applying new target state estimation techniques, new guidance laws, and robust autopilot designs to optimize missile trajectories for faster intercept and increased terminal accuracy.

- The goal is a fully integrated guidance and control system which is capable of providing higher single-shot-kill-probabilities for missiles such as AMRAAM. An additional goal is the development of an innovative guidance law to replace the time honored, but limited, "proportional navigation" which was invented in 1948.

- This technology is also applicable to the air-to-surface area.

MAJOR ACCOMPLISHMENTS

- Completed a system requirements flowdown of the Hammerhead program's performance objectives into a functional allocation of SAR seeker and free flight weapon specifications. Began detailed SAR seeker and weapon design modifications. Obtained GBU-15 flight vehicles for future integration with the GPS/INS guidance package and SAR seeker. Obtained GPS/INS guidance package components for preliminary testing. Began procurement of long-lead hardware items to support future SAR seeker fabrication.

- Completed the development of a six-degree-of-freedom-simulation for a SAR-guided GBU-15 weapon to support analysis activities under the Hammerhead program.

- Completed a Test Execution Plan and a draft Method of Test document for initial test planning associated with the Hammerhead program. Established a free flight weapon integration facility and technical support through the 46th Test Wing. Conducted preliminary weapon-to-aircraft compatibility analysis and coordination with the Air Force Seek Eagle Office.

- Completed development and demonstration of the Passive Adjunct Seeker Antenna for AMRAAM. Also completed design/development of Active Conformal Antenna under a Phase II Small Business Innovation Research (SBIR). Participated in adapting our conformal designs to meet antenna requirements for HARM Program Office (PMA-242) and the Advanced Anti-Radiation Guided Missile (AARGM) Program Office.

- Established a consortum between the Armament Directorate and a group of companies to conduct the Parallel Algebraic Logic (PAL) processor program. Under the PAL program the implementation of high speed hardware and high level image algebra software has allowed real time integration and processing of multiple sensor data for target identification. The PAL processor was provided to the Shands Research Hospital for use in a variety of medical applications.

- Downselected to one contractor on the Optical Processor Enhanced LADAR (OPEL) program to fabricate and captive flight test a light-speed optical correlator coupled with a solid state laser radar for target identification in clutter.

- Fabricated and demonstrated large format (512 x 512 pixels) staring imaging IR Multiple Quantum Well (MQW) focal plan arrays which will provide detection of long wave IR not presently possible today.

- Completed a state-of-the-art mobile test-bed called the MMW Analysis of Passive Signatures (MAPS).

- Demonstrated a 512 x 512 radiative element resistor array with a complete drive electronics suite for hardware in the loop simulations. This is the first time a 512 x 512 projection device has ever been driven at the speed (120 Hz) and resolution (14 bits) necessary for high fidelity testing of imaging infrared sensors.

- Delivered a 512 x 512 radiative element resistor array to the 46th Test Wing Guided Weapon Evaluation Facility for installation into their IR hardware-in-the-loop suite.

- Improved the target scene modeling capability of Irma under the Data Analysis and Modeling (DAAM) program. This resulted in the release of Irma 4.0 which has the unique capability to model correlated active and passive imagery in the infrared and millimeter wave wavebands and the development of a user friendly graphical user interface. The DAAM program was completed in FY96 and has been superseded by Multi Sensor Modeling and Analysis (MSMA). MSMA is comprised of three efforts: Modular Algorithm Concepts and Evaluation Tool (MACET), continued Irma refinement and validation, and Solid State LADAR Algorithm Development and Evaluation (SSLADE).

- Developed and exercised statistical and unconventional algorithm development approaches under the MACET environment. The MACET development Version 1.2 for passive IR, LADAR, and MMW channels was completed.

- Developed nonproprietary, government-owned, autonomous target acquisition (ATA) algorithms for solid state laser radar seekers. Greater than 90 percent probability of target classification of mobile targets was demonstrated with the algorithm developed under this in-house, contractor-supported SSLADE effort.

- Provided ten weeks testing in Kinetic Kill Vehicle Hardware-in-the-Loop Simulation (KHILS) facility for the Defense Nuclear Agency on nuclear effects and theater missile defense-type interceptor nuclear mitigation algorithms. Testing uncovered a failure mode due to nuclear effects that was never found with pure digital simulation. A mitigation technique was demonstrated.

- Successfully transitioned the Tri-Service Inertial Measurement Unit (IMU) into the Joint Direct Attack Munition (JDAM). The Fiber Optic Gyro (FOG) IMU program was completed, resulting in a functioning FOGIMU that can fully replace the Tri-Service IMU, with a cost savings of 25 percent per unit without sacrificing performance.

- The Tactical High Antijam GPS Guidance (THAGG) program was completed. THAGG, for the first time, demonstrated rapid direct P(Y)-code GPS satellite acquisition in a heavy jamming environment. Once acquired, THAGG tracks satellites in a multiple jammer environment in excess of 80 dB Jam-to-Signal ratios (J/S).

- Continued Advanced Guidance Law development with the investigation of the nonlinear controls. Tremendous theoretical strides have been made that can lead directly to improved autopilot and estimation algorithms. A method for directly accounting for actuator saturation has been investigated and shows promise.

- Completed anechoic chamber testing of antijam GPS receiver hardware.

- Completed hardware-in-the-loop testing of antimateriel submunition in preparation for flight tests.

- Completed baseline INS/GPS guided munition simulation with full satellite constellation over oblate rotating earth.

CHANGES FROM LAST YEAR

There were no major changes in this Thrust.

MILESTONES

AIR-TO-SURFACE

- MMW Analysis of Passive Signatures (MAPS) test-bed delivered in FY96. Begin data collection and phenomenology investigations to verify analytical models and form baseline for mission specific designs of passive MMW seekers.

- Conduct RASER determinations of exploitable MMW phenomenology for the improvement of smart munition guidance systems in FY96.

- Initiate a program to develop a laser radar brassboard to evaluate new low cost components and algorithms which will provide the next generation, high resolution seekers in FY96.

- Explore active and passive real beam MMW imaging technologies in FY96 and FY97 for application to a covert air-to-surface seeker.

- Contract for Advanced GPS Inertial Navigation Technology (AGINT) program was awarded in FY96. The program will produce a low cost, small, intelligent antijam GPS capability. The preliminary schedule has a breadboard delivered in FY98, a brassboard in FY99, and program completion by FY99.

- Complete development of closed-loop INS/GPS guided munition simulation to include capability to evaluate antijam technology response to all known jammer threats. Support antijam technology flight test program in FY97.

- A wideband passive MMW radiometer array will be delivered in FY97. This will provide a baseline for a cative flight test-worthy design

- Complete study for performance and affordability of advanced IR bolometric sensor in FY97.

- Predict, measure, and validate multidiscriminant IR and LADAR data in FY97.

- Target and background scene sequences will be generated for closed-loop testing of an infrared seeker and will be used to help demonstrate a high fidelity infrared scene projector in FY97.

- The OPEL contractor will assemble the LADAR seeker optical processor and conduct component and system laboratory testing in FY97. Tower tests, consisting of high speed processing of a large data base, will be conducted in FY97. Identification friend/foe (IFF) will be demonstrated under static but high clutter conditions in FY98.

- Demonstrate optical pulse injection for active LADAR scene projection in FY97. Integrate real-time simulation capability along with this projection capability for closed-loop LADAR hardware-in-the-loop testing by FY98.

- In FY97, the contractor will complete the demonstration of the 368 giga-operations per second (GOP) PAL I processor, and the assembly and test of the tera-op PAL II Mesh Connected Computer (MCC) and I/O chip(s) which will be designed, manufactured, and tested in accordance with standard commercial practices. The integrated circuit will be simulated using computer aided engineering tools to verify its design, performance, power requirements, and power dissipation. Prototype MCC and I/O chips and data sheet(s) describing the MCC chips will be completed in FY98. Packaging of the PAL II processor will be completed in FY99.

- In FY97, the MSMA program will increase the speed of operation, and increase the type of target signatures it generates. The Irma model will be upgraded to support the development of multimode air-to-air/air-to-surface munitions and be validated against measured imagery taken in laboratory and real world environments for real-time data analysis and algorithm development in FY98. After successful development of the top level functions and system validation, MACET will be interfaced to a real-time hardware system for demonstration purposes in FY99. SSLADE will develop critical mobile and fixed, high value, target acquisition, and classifier algorithms in FY99.

- Complete flight testing of an INS/GPS jam resistant receiver integrated within flight test vehicle in FY98.

- Deliver LADAR brassboard sensor from DASSL for use with the Small Smart Bomb program in FY98.

- Captive flight testing of the SAR weapon for the Hammerhead program will begin in FY98, followed by free flight demonstrations in FY99.

- Continue development of an even smaller and cheaper replacement for the FOGIMU. A Breadboard will be delivered in FY98, a brassboard in FY99, and completely tested in FY99.

- Demonstrate real time targeting for a SAR seeker using either on-board or off-board sensor information in FY01.

- Complete flight testing of precision guided small smart bomb with integrated seeker and GPS/INS guidance in FY01.

AIR-TO-AIR

- In FY96 apply signature modeling capability from the Irma program and the codes from the Composite, High Altitude, Maneuvering, Post-Boost Vehicle Program to air-to-air scene generation and analysis.

- Integrate conformal antenna design for the next-generation air superiority missile with high speed munition processor in FY97 and captive flight test the seeker in FY98.

- Autopilot development for agile, dual range missiles is expected to improve missile lethality by incorporating advances in automatic controls. Contract is expected to be awarded in FY97, Flight Control System design and simulation development 3Q98,

hardware-in-the-loop simulation in FY99, and flight tested in FY00.

- Begin developing and testing affordable, passive, electro-optical/infrared seekers which are sensitive to longwave infrared, multicolor, and polarization signatures to provide improved air-to-air terminal seekers in FY98.

- Begin Multimode Conformal Array Seeker Program using CAST antennas for RF portion in FY98.